POWER CONVERTER FOR AN ELECTRIC ENGINE START SYSTEM

1. Field of the Invention

[0001] This invention generally relates to electric engine start systems. More particularly, this invention relates to a power control arrangement in a system having an electric motor used to start an engine.

2. Description of the Related Art

[0002] Electric engine start systems typically include an electric motor associated with an engine, such as a gas turbine engine. The electric motor is powered to provide rotation to the engine during engine start up operations. In some situations, the electric motor is then used as a power generator after the engine has been running at a sufficient level. Example patents in this area include United States Patent Nos. 4,949,021 and 5,029,263.

[0003] Example electric start systems having fault tolerant capabilities are shown in U.S. Patent Nos. 6,018,233 and 6,037,752. Such systems include multiple power sources and loads that are connected by a switch matrix that uses multiple power converters. Such a system is relatively complex and can be overly cumbersome for some situations. There is a need for an arrangement that is more simple than previously proposed, relatively more complicated systems.

[0004] In some examples, a wound field synchronous motor is used to start the engine and then used as a power generator when the engine is running. The field of a wound field synchronous motor is controlled with an exciter and, therefore, the output voltage when the motor operates as a generator can be controlled within the

variable operating range of the engine. If a permanent magnet motor were to be used as the starter and generator in such a system, electric fields associated with a permanent magnet motor cannot be controlled because the varying engine speeds cause varying speeds in the motor. There is a need for controlling the generated power output from a permanent magnet motor, which can vary as the engine speed varies.

[0005] This invention provides a power control arrangement for utilizing a single permanent magnet motor for starting an engine and then generating power while the engine is running.

SUMMARY OF THE INVENTION

[0006] In general terms, this invention is a power control arrangement having a permanent magnet motor that is used for starting an engine and then used to generate power while the engine is running.

[0007] One example system designed according to an embodiment of this invention includes a permanent magnet motor that is adapted to be coupled with the engine such that the motor and engine rotate simultaneously. A first phase controlled rectifier is associated with the motor for selectively coupling the motor to a power source. A second phase controlled rectifier is associated with the motor for selectively coupling the motor to a load. The first phase controlled rectifier is switched to couple the motor to the power source during an engine starting operation. The second phase controlled rectifier is switched to provide power generated by the motor to the load when the engine is running.

[0008] In one example, the first and second phase controlled rectifiers are switched so that one is conducting while the other is not.

[0009] A power converter in one example is in series with the first and second phase controlled rectifiers. The first rectifier is between the power converter and the power source. The second phase rectifier in this example is between the power converter and the motor. In one example, the power converter is a pulse width modulating inverter that is capable of converting the power state for various kinds of electrically driven loads, which provides greater versatility with fewer components.

[0010] An example method of controlling power distribution using an engine starting system that has a permanent magnet motor associated with the engine includes coupling the motor to a power source using a first phase controller rectifier while starting the engine. Coupling the motor to a load using a second phase controlled rectifier provides power generated by the motor to a load when the engine is running.

[0011] The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiments. The drawings that accompany the detailed description can be briefly described as follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 schematically illustrates an engine start system designed according to an embodiment of this invention.

[0013] Figure 2 schematically illustrates selected portions of a second embodiment of an engine start system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0014] Figure 1 schematically shows a gas turbine engine assembly 20 that includes a power distribution system 22. The assembly 20 includes a gas turbine engine 24 and a permanent magnet motor 26 that is used for starting the engine 24. The permanent magnet motor 26 is also used to generate power for powering a load 28 when the engine 24 is running.

[0015] A first phase controlled rectifier 30 includes a rectifier bridge arrangement and is used for selectively coupling the motor 26 to a power source 32. The first phase controlled rectifier 30 provides a soft pre-charge function for a DC link capacitor bank 34. During an engine starting operation, the first phase controlled rectifier 30 insure a slow charge of the capacitor until a power ready signal indicates that variable power should be provided to the permanent magnet motor 26.

[0016] A power converter 36 is switched to couple the power source 32 to the permanent magnet motor 26 for providing variable voltage, variable frequency power to the permanent magnet motor 26 to start the engine 24. During the engine starting operation, a second phase controlled rectifier 38 is not enabled (i.e., turned off).

[0017] After the engine starting operation has been successfully completed, the first phase controlled rectifier 30 is disabled and the second phase controlled rectifier 38 can be enabled to selectively provide power generated by the motor 26 to the load 28. As known, when the engine 24 is running, the permanent magnet motor 26 will be rotating and generating electrical power. The second phase controlled rectifier 38 converts the variable AC voltage from the permanent magnet motor 26 into a constant DC voltage power state. The power converter 36 then

converts the DC power into AC power. In one example, the AC power preferably has a constant frequency and a constant voltage.

[0018] When the first phase controlled rectifier 30 is enabled, the second phase controlled rectifier 38 is disabled. When either one is turned on, the other is turned off so that the load 28 will not be directly coupled to the power source 32, for example.

[0019] The example of Figure 1 includes a controller 40 that controls the switching states of the phase controlled rectifiers 30, 38 and the power converter 36. A detector 42 associated with the permanent magnet motor 26 provides information to the controller regarding the operating state of the motor so that the controller 40 appropriately controls the switches of the power distribution system 22 to achieve a desired result. Given this description, those skilled in the art will be able to select from among various detecting and switching strategies to meet the needs of their particular situations.

[0020] In some situations, the load 28 may be particularly sensitive to any variations in frequency or voltage. The embodiment shown in Figure 2 includes a filter 50 that filters the power generated by the motor 26 before it is provided to the load 28. The filter 50 ensures that a sufficient quality of power is provided to the load 28.

[0021] In the illustrated example, the filter 50 includes a differential mode filter 52 and a common mode filter 54. Given this description, those skilled in the art will be able to select from among known filters to meet the needs of their particular situation.

[0022] By having first and second phase rectifiers 30 and 38 in series with the power converter 36 and controlling them as described above, the disclosed

examples provide the ability to power a permanent magnet motor to start an engine and then to use the permanent magnet motor as a power generator to supply power to a load when the engine is running. The disclosed examples utilize a single permanent magnet motor and a single power converter to achieve these functions. In the disclosed examples, the power converter 36 comprises a pulse width modulating inverter that is capable of handling various types of power conversion. For example, the disclosed pulse width modulating inverter is capable of handling three-phase power for AC motors, such as permanent magnet motors and induction motors. In one example, the pulse width modulating inverter is modified (not illustrated) such that a switched reluctance motor can be supported by an embodiment of this invention.

[0023] In another embodiment, the motor 26 regenerates power to the grid or other source under certain conditions. In such an example, the second phase controlled rectifier 38 selectively couples the motor 26 to the power source in addition to or in place of the powered load 28.

[0024] The preceding description is exemplary rather than limiting in nature. Variations and modifications to the disclosed examples may become apparent to those skilled in the art that do not necessarily depart from the essence of this invention. The scope of legal protection given to this invention can only be determined by studying the following claims.